

# Intake, performance, and blood parameters in young goats offered high forage diets of lespedeza or alfalfa hay

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## Abstract

July-born F<sub>1</sub> Boer x Spanish (BoerX), Nubian, and Spanish buck kids ( $n = 18$ ) were used in an experiment to evaluate the use of lespedeza hay in goat diets. Bucklings were weaned at 60 d of age and maintained on pasture and in pens, before being assigned to the experiment at 6 months of age. Kids were randomly assigned to six pens and stratified by breed. The two diets were ad libitum: (1) sericea lespedeza [*Lepedeza cuneata* (Dum.-Cours) G. Don; LESP] hay, or (2) alfalfa (*Medicago sativa* L.; ALF) hay. All animals received a 16% crude protein (CP) corn/cottonseed-based supplement offered at 0.5% of body weight (BW) per head/d. Total dry matter intake (DMI) was higher ( $P < 0.001$ ) for LESP-based (42.1 g/kg BW per day) than for ALF-based (38.7 g/kg BW per day) diets, and increased with time on trial for LESP, but not ALF (diet  $\times$  time interaction:  $P < 0.05$ ). Bucks offered ALF had higher average daily gain (ADG; 103 versus 56 g/d;  $P < 0.01$ ) and final BW (31.3 versus 26.6 kg;  $P < 0.05$ ) than those offered LESP. Initial body weights were higher ( $P < 0.001$ ) for Nubian (24.7 kg) compared to BoerX (18.5 kg) or Spanish (19.7 kg) which were similar. This same trend was observed for final body weights ( $P < 0.05$ ; Nubian 33.4 kg; BoerX 25.9 kg; Spanish 27.3 kg). There were no breed differences ( $P > 0.10$ ) in ADG (mean 79 g/d). Bucks offered the ALF-based diet had higher ( $P < 0.001$ ) plasma concentrations (mg/dl) of blood urea nitrogen (BUN; 21.1 versus 10.7) and glucose (67.7 versus 59.5) and lower ( $P < 0.001$ ) creatinine (0.53 versus 0.62 mg/dl) compared to kids offered the LESP-based diet. Blood glucose concentrations were highest ( $P < 0.001$ ) for Nubian (66.3 mg/dl) and lowest for Boer cross (60.9 mg/dl); Spanish was intermediate (63.6 mg/dl). Creatinine levels were similar among breeds (mean 0.57 mg/dl). More research is needed to evaluate goat breed, forage species, stage of forage maturity, condensed tannins, and supplementation effects on nutrient utilization by finishing goats. © 2004 Elsevier B.V. All rights reserved.

**Keywords:** Goats; Lespedeza; Alfalfa; Intake; Blood

## 1. Introduction

Alfalfa (*Medicago sativa* L.) is the predominant pasture legume for many classes of livestock (Van Keuren and Matches, 1988) and alfalfa hay is often used to

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supply crude protein in finishing diets for ruminants. Alfalfa is a tall growing, winter hardy plant that produces high yielding, high quality forage that is readily consumed by goats (Fisher et al., 2002) and supports superior weight gains (Gelaye et al., 1990).

Meat goats will perform well in production systems when management practices match eating behavior; goats prefer 50% of the daily ration from browse or woody plants (Luginbuhl et al., 1996). Sericea lespedeza [*Lespedeza cuneata* (Dum-Cours) G. Don] is a tall growing, coarse-stemmed perennial, drought-tolerant legume that is productive on acid and poor fertility soils (McGraw and Hoveland, 1995) typical of the Appalachian region of the USA. Sericea lespedeza is often grown as an alternative to alfalfa in hill-land agriculture, but common sericea contains high levels of tannins (Terrill et al., 1989) that can restrict intake and reduce overall weight gains by livestock (Burns et al., 1972; Schmidt et al., 1987). Goats tend to tolerate and perform well when consuming high tannin containing plants (Silanikove et al., 1996).

Concentration of specific blood components have been used to monitor nutrient status (e.g. serum glucose and blood urea nitrogen [BUN], Hammond et al., 1994) and have been associated with overall muscle mass (e.g. creatinine, Morgan et al., 1993; Myer et al., 1996) in ruminants.

Efforts are underway in the USA to define breeds and refine crossbreeding programs for improving growth rate and carcass yield of meat-type goats (Gipson, 1996) due to the increased demand for chevon (Escobar et al., 1993). Carcasses from uncastrated young bucklings are preferred by the various ethnic groups in the USA. Evaluation of performance efficiency and nutrient status when goat bucklings are finished on high forage-based diets is needed for a fast growing niche market potential for farmers. Research on the use of sericea lespedeza in livestock finishing diets is limited. Therefore, the objective was to determine intake, weight gain, and selected blood metabolites when growing goat bucklings were offered energy supplemented diets containing lespedeza or alfalfa hay.

## 2. Materials and methods

Care of bucklings and ruminally cannulated steers and the research protocols used in this experiment followed accepted guidelines (Consortium, 1988).

Eighteen meat goat bucklings were used in the experiment representing three breed types: Boer X Spanish (BoerX), Nubian, and Spanish. Before the experiment started, all bucklings were weaned at 60 d of age and grazed a common grass pasture until 6 months of age. Bucklings were vaccinated against tetanus and *Clostridium perfringens* types C and D and dewormed with levamisole (11.8 mg/kg BW administered orally). The trial began February 14. Bucklings were stratified by breed and assigned to six pens; three animals per pen; each pen contained all three breeds of goats.

Forage-based diets were: (1) alfalfa (*Medicago sativa* L.) hay, or (2) sericea lespedeza [*Lespedeza cuneata* (Dum-Cours) G. Don cv. Serala] hay. Chopped hays (average particle length 11 cm) were offered ad libitum at 15–20% above projected daily intake. All animals were fed a 16% crude protein (CP) corn (*Zea mays* L.)-cottonseed (*Gossypium* spp.)-based supplement at 0.5% of body weight (BW) per head/d and had free access to water and a trace-mineral mix containing ammonium chloride. Whole corn was ground to pass a 1.9-cm screen in a hammermill prior to mixing.

Animals were adjusted to the hays and supplemental feeding for 3 weeks prior to the start of the experiment with both groups receiving a mixture of the two hay types. After 3 weeks, pens were randomly assigned a hay for the remainder of the experiment. Hay intake was measured on a pen basis at 3-week intervals after the start of the experiment. In the morning after removal of the hay orts, the supplement was fed and allowed to be consumed prior to filling bunks with chopped hay. During collection periods, hay, supplement, and hay orts samples were bulked by pen and subsamples were used for dry matter (DM) determinations. Information was used to calculate hay intake, supplement intake, and total dry matter intake (DMI) on a per pen basis as breed was confounded within each pen.

During the 100-d feeding trial, BW was recorded on individual animals in each pen at the start of the experiment and individual, interim pre-prandial weights were recorded at 14-d intervals and used to adjust supplement level. Pre-prandial blood samples were collected at the start (February 14), middle (March 27), and end (May 15) of the experiment via jugular venipuncture into sterile blood tubes containing EDTA from each animal. Blood was stored on ice after collection until centrifuged at  $2300 \times g$  for 15 min to obtain plasma. Plasma was stored at  $-20^{\circ}\text{C}$  for about 90 d until ana-

lyzed for blood urea nitrogen (BUN), glucose, and creatinine using automated procedures on the Ciba-Corning Express Plus Chemistry Analyzer<sup>1</sup> (Ciba-Corning Diagnostics Corp., Medfield, MA).

Hay and supplement samples were ground to pass a 1-mm screen in a Wiley<sup>1</sup> mill and were analyzed for DM, ash (AOAC, 1990); total N (Carlo-Erba Ea 1108 CHNS elemental analyzer<sup>1</sup>, Fisons Instruments, Beverly, MA); neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Goering and Van Soest, 1970; Van Soest et al., 1991); and in vitro organic matter (OM) disappearance (IVOMD) (Tilley and Terry, 1963; Moore, 1970). The IVOMD procedure used rumen fluid obtained from two ruminally cannulated steers offered orchardgrass (*Dactyloides glomerata* L.), alfalfa, and sericea lespedeza hay. Samples of hays and supplements were sent to Penn State University for determination of Folin reactive phenolics and condensed tannin (CT) concentration using high pressure liquid chromatography procedures and soluble protein (Appel et al., 2001).

Intake, growth and blood data were analyzed using the general linear model of the Statistical Analysis Systems (SAS, 1998). Body weights, weight gained, and blood data used individual animal as the experimental unit and were analyzed with a model that included time, breed, and diet as main effects with repeated measures analysis. Intake used pen as the experimental unit using time and diet as main effects, with a repeated measures analysis; intake by breed was confounded within pen and is presented as average intake by the animal in each pen. All references to differences between or among treatment means refer to  $P < 0.05$  unless otherwise stated.

### 3. Results and discussion

Nutrient composition and tannin concentrations of the hays and supplement are presented in Table 1. Alfalfa hay was considered of higher quality (higher CP and IVOMD) than LESP although NDF concentrations were similar and LESP had lower ADF levels. In addition, the condensed tannin concentration per unit of

Table 1  
Nutritive value of hays and corn-based supplement offered goat bucklings

Item	Lespedeza hay	Alfalfa hay	Supplement
DM, %	93.3	93.6	92.8
Composition (DM base)			
CP, %	11.2	18.7	15.5
NDF, %	60.6	59.9	25.3
ADF, %	39.4	46.1	15.5
IVOMD, %	28.5	52.3	73.3
Condensed			
Tannin (soluble protein), mg/mg	23.1	0.24	1.02

Abbreviations: DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; IVOMD; in vitro organic matter disappearance.

soluble protein was higher for LESP (23.1) compared to ALF (0.24) and the supplement (0.04).

Sericea lespedeza offered to sheep had low digestibility due to high tannin concentration (Terrill et al., 1989). Tannin containing forages had slower rates of digestion in the rumen, but greater ruminal escape values (Albrecht and Broderick, 1990). Haggerman and Robbins (1987) reported that protein–tannin complexes are insoluble, but more soluble forms occur. Condensed tannins inhibited the growth of several microorganisms (Field and Lettinga, 1992) and the enzyme activity of rumen microbes (Bae et al., 1993). Turner and Neel (2003) observed longer lag times and lower IVOMD as supplemental quebracho condensed tannin levels increased.

#### 3.1. DMI

Goats were observed each day to be sure supplement was fully consumed before the hays were offered; supplement was consumed equally among the breeds within each pen. Daily total DMI of hay and supplement was higher ( $P < 0.001$ ) for LESP (42.1 g/kg BW) than for ALF (38.7 g/kg BW) diets, and increased with time on trial for LESP, but not ALF which declined (diet  $\times$  time interaction:  $P < 0.05$ ); mainly as a result of increased LESP hay intake over time compared to ALF (Fig. 1). When averaged over the five periods and on a per pen basis, mean hay intakes were similar ( $P > 0.10$ ) for bucklings offered LESP (2.61 kg/pen) or

<sup>1</sup> Trade names are used for the convenience of the reader and do not imply endorsement by USDA over comparable products.

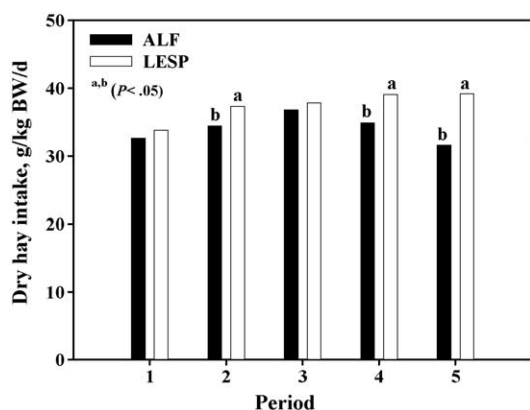


Fig. 1. Mean daily dry hay intake (g/kg BW) by individual period (3 weeks apart) when goat bucklings were offered sericea lespedeza (LESP) or alfalfa (ALF) hay plus an energy supplement.

ALF (2.56 kg/pen). Overall, mean daily hay intake per kg BW (pen average weight) was greater ( $P < 0.001$ ) for buckling offered LESP (37.5 g/kg BW/d) than those offered ALF (34.1 g/kg BW/d).

Gelaye et al. (1990) reported alfalfa hay (18% CP) intake of 2.8% BW compared to 3.4% here for goats of similar size. Intakes of 2.5–4.4% BW have been reported for goats offered various forages and browses (Brown and Johnson, 1985; Louca et al., 1982). Terrill et al. (1989) reported reduced dry matter intake, fiber disappearance, and nitrogen (N) digestibility as CT concentration increased in sericea lespedeza [*Lespedeza cuneata* (Dum-Cours) G. Don] offered to sheep.

A supplement containing both a carbohydrate (corn) and fibrous by-product (cottonseed hulls) was also offered to the goats in the study. Supplementation of forage diets with fibrous by-product feeds usually resulted in increased intake of low-quality forages (Bowman and Sanson, 1996). When compared to sheep, goats digest low quality (low N and digestible OM) feeds more efficiently (Alam et al., 1985). In general, depression of forage intake with high carbohydrate supplementation is greater with high-quality forages than low-quality forages (Minson, 1990). Studies using goats as the ruminant species and supplemented with different grain sources are limited (Cerrillo et al., 1999).

The supplement used in the study also contained cottonseed hulls which also contains CT. Commercial cottonseed hulls usually contain 3.2–6.5% CT with 80% in

bound form (Yu et al., 1993). Yu et al. (1995) reported that the CT in cottonseed hulls was not a significant factor in reducing rumen protein solubility. Skene and Booker (1995) isolated a ruminal bacterium from feral goats capable of enzymatically breaking down tannin. An enterobacteria capable of degrading tannin–protein complexes has been identified in the caecum of the koala (Osawa and Sly, 1992). Rumen microorganisms adapted to the presence of tannins with prolonged feeding by inducing enzymes capable of degrading tannins (Brooker et al., 1994). Goat bucklings in this experiment were adapted to the diets for 3 weeks prior to the start of the experiment, but this may not have been ample time for rumen microorganisms to adjust to the tannins in LESP. Intakes of LESP were higher than ALF which suggested high fiber digestibility. Increasing intake of LESP hay over time probably was a result of further rumen adaptation to lower quality, tannin-containing LESP compared to ALF.

Even with high CT in the diet, bucklings offered LESP were still able to maintain higher DMI than animals offered ALF. Tannins in forage plants can have positive or negative effects on intake, digestion in the rumen, and overall performance, depending on the type and concentration of compounds that are present in the diet. Plants which contain moderate levels of tannins provide both degradable and non-degradable rumen protein are more effective as protein supplements (Kaitho et al., 1998). The ability of tannins to complex with protein and other molecules is dependent upon their structure (Barahona et al., 1997) and specificity (Haggerman and Butler, 1981). The hay making process may have decreased biological activity or even destroyed or enhanced specific tannins. More detailed research is needed to accurately identify and classify tannins in order to investigate influences on intake, nutrient-use, and performance by goats.

### 3.2. Weight gain

Overall, bucklings offered ALF had a higher ADG (103 versus 56 g/d;  $P < 0.01$ ) and final BW (31.3 versus 26.6 kg;  $P < 0.05$ ) than those offered LESP (Table 2). Initial body weights were higher ( $P < 0.001$ ) for Nubian (24.7 kg) compared to BoerX (18.5 kg) or Spanish (19.7 kg) which were similar. This same trend was observed for final body weights ( $P < 0.05$ ; Nubian 33.4 kg; BoerX 25.9 kg; Spanish 27.3 kg). There

Table 2

Beginning and ending body weights (BW) and average daily gain (ADG) when three breeds (BoerX, Nubian, or Spanish) of goat buckling were offered alfalfa (ALF) or sericea lespedeza (LESP) hay plus supplement

Item	Starting BW, kg	Ending BW, kg	ADG, g/d
Diet			
LESP	20.1	26.9 <sup>b</sup>	56 <sup>d</sup>
ALF	20.1	31.3 <sup>a</sup>	103 <sup>c</sup>
Breed			
BoerX	18.5 <sup>f</sup>	25.9 <sup>b</sup>	75
Nubian	24.7 <sup>e</sup>	33.4 <sup>a</sup>	87
Spanish	19.7 <sup>f</sup>	27.3 <sup>b</sup>	75

<sup>a,b</sup>Means within an item and column with unlike superscripts differ ( $P < 0.05$ ).

<sup>c,d</sup>Means within an item and column with unlike superscripts differ ( $P < 0.01$ ).

<sup>e,f</sup>Means within an item and column with unlike superscripts differ ( $P < 0.001$ ).

were no breed differences ( $P > 0.10$ ) in ADG (mean 79 g/d).

Goats offered ALF (0.37) had a lower feed:gain ratio and required about 50% less DM per unit of gain than animals offered LESP (0.75). Gelaye et al. (1990) reported ADG of 46 g/d for goats, including Nubian, offered ALF hay and of similar size as was used in this experiment. Boer and boer-cross have been reported to have growth rates of over 200 g/d (McGregor, 1985). Comparisons of the production potential of goat breeds is difficult because of the diversity of forages and supplements used in the wide range of production environments (Warmington and Kirton, 1990).

Weight gain by goats is sensitive to protein and energy content of forages (Ash and Norton, 1987). Kaitho et al. (1998) speculated that sheep fed high-tannin legumes had an overall shortage of rumen-degradable-N resulting in impaired fiber digestibility and reduced weight gain. Crude protein in low-tannin sericea was more highly digested than high-tannin sericea (Donnelly et al., 1971). Even though CP content of LESP was lower than ALF and the ALF hay contained 0.24 mg condensed tannin/mg soluble protein and lespedeza contained 23.1 mg condensed tannin/mg soluble protein (Table 1), the CP in the diet was not considered inadequate for growth (NRC, 1981) or rumen function.

High CT in the LESP hay probably interfered with protein metabolism and overall performance. Total CT

was determined, but individual biologically active tannins were not quantified or identified in this experiment. Condensed tannins contained in plants can bind dietary protein at ruminal pH thereby reducing breakdown by microorganism and increasing the rumen escape value of protein. The tannin–protein complex is dissociated in the acidic environment of the abomasum and intestinal absorption of protein and overall N-use is increased. Douglass et al. (1995) reported greater live weight gain when lambs grazed birdsfoot trefoil versus alfalfa due to CT influences in the ruminant digestive tract. Medium concentrations of CT (45–55 g CT/kg DM) in forages can improve N-use efficiency in ruminants (Min et al., 2003). Forages containing 20–40 g CT kg<sup>-1</sup> DM have been reported to increase rumen escape value of herbage (Barry, 1985, 1989; Terrill et al., 1992) and improve livestock weight gain.

### 3.3. Blood parameters

Overall, bucklings offered ALF had higher ( $P < 0.001$ ) plasma concentrations (mg/dl) of glucose (67.7 versus 59.5) and lower ( $P < 0.001$ ) creatinine (0.52 versus 0.61 mg/dl) compared to kids offered the LESP (Table 3). Blood glucose concentrations were highest ( $P < 0.001$ ) for Nubian (66.3 mg/dl) and lowest for BoerX (60.9 mg/dl); Spanish was intermediate (63.6 mg/dl). Creatinine levels were similar among breeds (mean 0.57 mg/dl).

There was a time  $\times$  diet interaction for BUN (Fig. 2). The BUN concentrations from ALF-fed bucklings were

Table 3

Selected blood parameters when three breeds (BoerX, Nubian, or Spanish) of goat bucklings were offered lespedeza (LESP) or alfalfa (ALF) hay plus supplement

Item	BUN, mg/dl	Glucose, mg/dl	Creatinine, mg/dl
Diet			
LESP	10.7 <sup>d</sup>	59.5 <sup>d</sup>	0.62 <sup>d</sup>
ALF	21.1 <sup>c</sup>	67.7 <sup>c</sup>	0.53 <sup>c</sup>
Breed			
BoerX	16.6 <sup>a</sup>	60.9 <sup>b</sup>	0.60
Nubian	14.2 <sup>b</sup>	63.6 <sup>a,b</sup>	0.55
Spanish	16.9 <sup>a</sup>	66.3 <sup>a</sup>	0.57

<sup>a,b</sup>Means within an item and column with unlike superscripts differ ( $P < 0.01$ ).

<sup>c,d</sup>Means within an item and column with unlike superscripts differ ( $P < 0.001$ ).



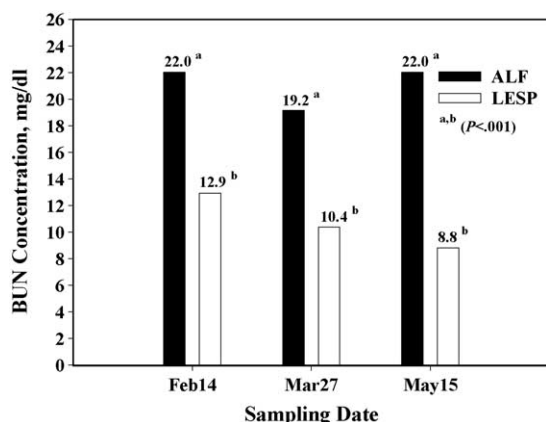


Fig. 2. Interaction of time vs. diet for blood urea nitrogen (BUN) when goat bucklings were offered lespedeza (LESP) or alfalfa (ALF) hay plus supplement.

relatively the same on the three sampling dates, but BUN levels from LESP-fed animals declined, resulting in a greater magnitude of difference relative to ALF-fed animals at each sampling date. There was no time  $\times$  diet interaction for glucose or creatinine.

There was a breed  $\times$  diet interaction for BUN (Fig. 3) in that the magnitude of difference between Spanish goats maintained on LESP or ALF was not as great as the magnitude of difference in BoerX and Nubian offered LESP or ALF. Overall, BoerX and Nubian had higher ( $P < 0.01$ ) BUN compared to Spanish (Table 3) as a result of the higher BUN values in ALF-fed animals.

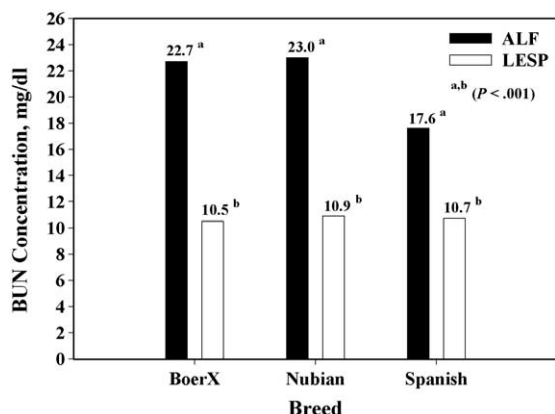


Fig. 3. Interaction of breed vs. diet for blood urea nitrogen (BUN) when three goat breeds (BoerX, Nubian, and Spanish) were offered lespedeza (LESP) or alfalfa (ALF) hay plus supplement.

Comparisons of blood parameters on individual goat breeds maintained on a wide variety of forages and supplements is tenuous. Differences in BUN levels among various goat breeds have been reported by [Sahlu et al. \(1993\)](#). Observed BUN (average 21.1 mg/dl) and plasma glucose (67.7 mg/dl) concentrations were similar to those reported by [Gelaye et al. \(1990\)](#) when dairy goats were offered ALF hay of similar nutritive value without grain supplementation (20.0 and 69.5 mm/ml, respectively). [Turner and Neel \(2003\)](#) observed similar BUN level when Boer-cross goats were offered ALF hay. [Hart and Sahlu \(1993\)](#) reported a breed  $\times$  forage quality interaction for plasma urea nitrogen levels.

Concentration of blood components of goats were used to monitor nutrient status (e.g. serum glucose) and blood urea nitrogen (BUN) and associated muscle mass (e.g. creatinine). Ruminants are not efficient utilizers of dietary protein ([Beever, 1982](#)). A positive correlation exists between level of protein (N) intake and BUN concentration ([Pfander et al., 1975](#); [Preston et al., 1965](#); [Karnezos et al., 1994](#)). In ruminants, BUN can be influenced by dietary N-to-energy ratio, level of forage intake, and protein degradability in the rumen ([Hammond et al., 1994](#)). Feeding cattle on a low nutritional plane decreased metabolic body rate and the required maintenance energy ([Hornick et al., 2000](#)); variation in the ability of goat genotypes to minimize maintenance energy required during periods of low energy intake has been reported ([Silanikove, 2000](#)). Goats offered LESP had lower BUN concentrations probably as a result of the lower total N and energy consumption relative to ALF. Higher CT concentrations in LESP may have further reduced availability of degradable protein in the rumen compared to ALF, resulting in a further decrease in BUN concentration. The BUN concentration in ruminants has been used as an indicator of excess N consumption relative to energy ([Hammond et al., 1994](#)). The N:energy ratio in the LESP plus energy supplemented diet probably resulted in a lower, but not optimal, ratio compared to goats offered ALF plus energy supplement.

Metabolism of creatine in muscle results in creatinine production; urinary creatinine has been used as an index of total muscle mass or the turnover of the protein pool in the body ([Xue et al., 1988](#)). Creatinine levels have been used to reflect muscle protein mass in lambs ([Myer et al., 1996](#)) and bulls ([Morgan et al., 1993](#)). Increasing protein intake had no effect on

plasma creatinine concentrations (Marini et al., 2004). It follows that serum creatinine concentration may be positively related to turnover of the protein pool in ruminants. Concentrations of CT in LESP may have interfered with protein uptake from the small intestine resulting in a greater need for muscle protein (amino acids) to be liberated and used to support gluconeogenesis, since forage quality of the LESP was lower compared to ALF. A lower blood glucose was also observed in LESP-fed animals which would be consistent with tissue metabolism.

#### 4. Conclusions

Lespedeza hay containing condensed tannins did not reduce palatability, as consumption by goat bucklings was comparable to or actually exceeded that of alfalfa hay. Weight gained was reduced when bucklings were offered the lower quality (low CP and IVOMD) lespedeza hay plus energy supplement compared to alfalfa hay plus supplement. Concentration of blood components of goats that were used to monitor nutrient status (e.g. serum glucose and BUN) and associated muscle mass (e.g. creatinine) between the two diets suggested that animal offered LESP were mobilizing muscle protein to supply needed energy; breed of goat is another important factor to consider when finishing goats on high forage diets with supplementation in order to optimize nutrient use. More research is needed that evaluates small ruminant breed differences, type and maturity of forage, and condensed tannins with various supplementation strategies in order to develop finishing systems for goats.

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